STRATEGY RESEARCH PROJECT

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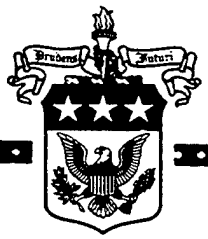
STRATEGIC MODEL FOR FUTURE GEOSPATIAL EDUCATION

BY

GARY A. HACKER

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USAWC STRATEGY RESEARCH PROJECT

Strategic Model for Future Geospatial Education

by

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ABSTRACT

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Geospatial information is the hydrographic, topographic, and aeronautical foundation of battlefield visualization and global command and control systems. Increases in computing technology combined with unclassified access to high resolution satellite imagery, geospatial information, and positioning accuracy provided by the Global Positioning System (GPS) will allow users in the field to create their own geographic decision aids and reference graphics. Joint doctrine currently under final stages of review clearly places the burden on the military services and intelligence agencies to create Geospatial Information Specialists at all levels from tactical to strategic. Implementation of this new doctrine will create a huge training void that cannot be satisfied by existing Department of Defense (DoD) and Intelligence agency training outlets. This research paper provides evidence that this training void can be overcome by adapting the Global University model for engineering education to the US Government's existing military and civilian geospatial information training infrastructure.

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STRATEGIC MODEL FOR FUTURE GEOSPATIAL EDUCATION

"We will have American industry providing for national defense, but we will not have a national defense industry."[1]

--Norman R. Augustine,
Chairman Lockheed-Martin

Nowhere is the above quotation truer than in the area of geospatial information handling and processing. This area was once the exclusive purview of governments because of the tremendous expense of collecting, analyzing, and creating end-user earth science products. Recent advances in computer capabilities and the successful transfer of Department of Defense (DoD) positioning and imaging technology to the private sector are rapidly moving geospatial information handling and processing into the realm of profitability for large and small businesses.

This technological explosion, combined withthe outsourcing recommendations of the National Performance Review[2], the Defense Reform Initiative[3] and the Federal Property and Administrative Services Authorization Act of 1992,[4] are forcing federal mapping agencies to contract out much of their geospatial information collection and processing activities to the rapidly growing private sector.

Draft Joint Publication 2-03 "Joint Tactics, Techniques, and Procedures for Geospatial Information and Services Support to Joint Operations" recognizes that evolution of the digital battlespace requires our soldiers, sailors, airmen, and

Marines to become geospatial-processing experts.[5] This evolution will undoubtedly place tremendous pressure on the DoD geospatial training community to make experts of many military service personnel. Add to this pressure the competition of a rapidly growing private sector trend for similarly trained personnel it is easy to see the need for a dramatic increase in the availability and quality of geospatial information handling and processing education.[6]

Unfortunately, geospatial information handling and processing technology is evolving much faster than industry and academia's ability to adequately train and educate future geospatial information specialists.[7] Keeping up with government and industry's demand for trained geospatial information specialists dictates a new approach to technology training that will require establishment of unprecedented partnerships between government, industry and academia.

MAPMAKING AND THE GEOSPATIAL ERA

Prior to 1993, mapmaking in the United States used technology virtually unchanged from World War II. Map-making techniques prior to 1993 generally required six steps:[8]

1. Acquisition of aerial imagery from government-owned air- or space-borne platforms;

2. Processing that imagery using expensive photogrammetric equipment run by highly skilled image analysts and photogrammetrists;

3. Transformation of the processed information into a cartographic manuscript requiring the skills of a highly trained cartographer;

4. Color separation of the manuscript into photographic negatives and printing plates requiring large format cameras, expensive photographic materials, and skilled photographers and photographic technicians;

5. Printing, folding, and packaging of finished maps by expensive printing presses, cutters, folders, and packaging machines operated by highly skilled lithographers and product finishers;

6. Finally, warehousing and distribution of final hardcopy map products requiring warehouse space, remote depots, warehouse operators, and logisticians to get finished maps to customers all over the world.

The geospatial era,[9] which began in 1993, is most notably marked by the near simultaneous introduction in the public sector of three technologies heretofore virtually reserved for government use: high-resolution digital satellite remote sensing imagery (RSI)[10], geographic information systems (GIS)[11] and Global Positioning System (GPS).[12] These three technologies melded together with today's information technology devices radically altered the six-step mapmaking process.

Whereas in the past only the United States government had remote sensing satellites, today the French, Russians, Japanese, Canadians, and Indians are all marketing satellite RSI at competitive prices. Indeed, the US Government has licensed previously classified imaging technology to US companies who will be flying very high resolution imaging satellites by the year 2001.[13] Thus, the pre-1993 step of government mapmakers using government-owned air- or space-borne imagery platforms to acquire imagery is transitioning to government and private

industry geospatial information producers purchasing commercial imagery from a variety of vendors.

Step two of the mapmaking process previously involved the use of million dollar pieces of photogrammetric equipment operated by skilled photogrammetrists. These photogrammetrists used a combination of photo analysis and cartographic skills to create controlled base manuscripts for cartographers to build upon.[14] In the geospatial era this expensive photogrammetric equipment is replaced by inexpensive computers displaying digital remote sensing imagery (RSI) allowing operators to view the imagery in three-dimensions. Operators analyze the imagery and extract geospatial information directly into a Geographic Information System (GIS).[15]

Step three, transformation into a cartographic manuscript, was done in the past by a cartographer whose job was to generate unique maps based on the intended use of the map. Thus, topographic maps and aeronautical charts created over the same geographic area required two cartographers with different skill sets to create the individual map products. Now, geospatial data are collected into multi-use databases. Using a high-speed computer and a GIS with a series of pre-defined data filters an operator may create a wide variety of cartographic renditions nearly automatically.

In the geospatial era, steps four, five, and six of the pre-1993 mapmaking process are virtually eliminated as mapping products generated with GIS can be highly customized, output on color printers and duplicated (if need be) by high-speed color copying machines.

Clearly, this shift from traditional cartography to the geospatial era has created two opportunities:

a) It has created an environment for private industry to profit in a technological area previously the exclusive purview of governments;

b) End users of geospatial data now have the capability to create and promulgate their own views of the world.

THE VOID IN GEOSPATIAL INFORMATION PROCESSING EDUCATION

Since the government in the pre-geospatial era had a virtual lock on the mapping and imagery analysis "market," it also had to rely on itself to feed the market with trained photogrammetrists, cartographers, and image analysts. Department of Defense activities created their own schools teaching these disciplines to the uniformed military and to this day have maintained a high level of proficiency and expertise at such institutions as the National Imagery and Mapping College and the military services' intelligence schools.[16] On the other hand, DoD civilians and employees of other executive agencies of the government attended large research universities where the government had carefully cultivated comprehensive teaching and research programs in the mapping and photogrammetry technology areas. Up through the late 1980's these universities, never numbering more than 20 nationwide, relied nearly totally on government funding--both direct research grants and full-paid graduate school government

student tuition to effectively maintain their geospatial information-related activities.[17]

Declining cartography and photogrammetry student populations and research grants resulting from government downsizing and budget cuts that started in the late 1980's forced many of these research universities to focus less on teaching and more on industry-sponsored research activities and consulting in the burgeoning RSI/GIS/GPS technology areas. However, industry was filling many of its geospatial expertise voids with former government employees and military personnel who were "victims" of downsizing and outsourcing. The research universities have remained focused on RSI/GIS/GPS research while opting to let smaller universities and colleges provide basic undergraduate geospatial education.[18]

Smaller universities and colleges have relatively quickly added bits and pieces of RSI/GIS/GPS education to their curriculum. Over the last four to five years there has been a tremendous explosion in the number of institutions offering some form or another of RSI, GIS, or GPS courses, with nearly 800 around the world now offering at least one RSI/GIS/GPS course.[19]

Unfortunately, a lack of geospatial education standards (or core curriculum) coupled with the inability of these smaller universities and colleges to find a common academic home for geospatial education[20] has led to a lethargy in development of comprehensive geospatial training programs for the private sector.

On the government side, the DoD training institutions have done a superb job of creating and maintaining cutting edge RSI/GIS/GPS courseware.

Unfortunately, government downsizing and reduced funding for geospatial training portends a gradual reduction in the quality and availability of geospatial education available from DoD institutions. No doubt, quality of education will suffer as government expertise is lost to the private sector and course availability will decline as reduced funding results in fewer course offerings.

Thus the void in geospatial education is the result of:

(a) Large research universities virtually abandoning "bulk" teaching of geospatial-related subjects to concentrate on research grants and consulting.

(b) The lack of a geospatial core curriculum and confusion over which academic departments "own" geospatial education causing smaller universities and colleges to very cautiously create geospatial information degree programs.

(c) Government funding and expertise drying up as Congress and DoD recognize the rapid transition of geospatial information processing dominance from the government to the private sector.

WHAT SHOULD THE U.S. GOVERNMENT DO TO HELP FILL THE GEOSPATIAL INFORMATION EDUCATION VOID?

The U.S. government has two alternatives. The first option is to do nothing and let academia, industry, and the international geospatial community sort out the confusion. The second option is to take the technology and educational material that the government has accumulated over nearly eight decades of dominance of the geospatial information technology area and partner with industry, academia, and

the international geospatial community to create the educational slice of Wood's proposed "Global Spatial Data Infrastructure."[21]

If option one is followed, it may take years, if not decades, for the entire geospatial community to create both educational standards and adopt geospatial data standards if there is no government participation in the solution. Also, because geospatial technology is progressing so quickly it makes it even more difficult for industry, academia, and the international geospatial community to focus in on standards. Secondly, a lack of government participation gives the remaining players the opportunity to develop and determine both geospatial education standards and geospatial data standards. If industry and academia adopt standards contrary to those already adopted by government agencies, the government will have to play an expensive game of catch up to adhere to the new standard. Since Congress is not likely to fund government projects that do not adhere to readily available industry standards, government agencies will wind up converting all their training materials and data holdings into the new standard. There appears to be only one benefit to doing nothing as option one dictates--there are no up front costs to the government for doing nothing. The costs creep in when counting lost time in waiting for private industry and academia to finally agree on standards, and the massive conversion costs when government starts adapting their data and training to the new standards.

Option two, government partnering with industry, academia, and the international geospatial community to transfer their wealth of geospatial information technology and training also has strengths and weaknesses. The main

weakness is that government agencies assuming leadership positions within the community during the technology transfer phase must make significant commitments of personnel and other resources to effectively make the transition. Representation and/or leadership in national and international standards committees are perhaps the most costly commitment. The primary strength is that for a relatively small near term cost in personnel and resources, the government can ensure that US industry and academia benefit from decades of geospatial information expertise. Industry and academia will be able to focus on building onto an already sound geospatial education and technology foundation rather than spending years trying to cover the same ground. Moreover, once industry and academia begin providing the type of education and training that government institutions currently provide, government institutions can potentially eliminate their indigenous basic training curricula. The government will be able to rely on industry and academia to provide basic geospatial education to employees and contractors. The government institutions can then focus their training efforts on advanced and/or militarily unique topics.

In summary, option two provides more benefits for both the government and the geospatial information community as a whole. This observation is also recognized by other government agencies, as William Wood, Director of the Office of the Geographer and Global Issues, US Department of State, puts it quite eloquently:

> Without responsible government-led guidance, the potential benefits of useful geographic information can easily be frittered away, benefiting only that minority of the world's population that is well off and thus

> needs it least. At the same time, a GSDI [Global Spatial Data Infrastructure] is not a Big Brother mechanism for interfering in an expanding geospatial marketplace. It is a cooperative means to lay down some of the rules for geospatial data quality and transactions and to ***help educate new users of this type of information***.(emphasis added)[22]

How to accomplish Wood's Global Spatial Data Infrastructure? The answer is in two parts--adoption of international geospatial information data standards and comprehensive development of an educational outreach program. The two nearly go hand in glove, for using the data standards in the educational context creates a new knowledge base of geospatial information processing experts who are intimately familiar with the proposed data standard. Here is where the government can best influence the process by:

(a) Making available the majority of its unclassified holdings of geospatial information in a standard international geospatial information format, and

(b) Aggressively inserting the vast storehouse of DoD's geospatial information educational courseware into mainstream academia via an unprecedented geospatial community outreach program.

Step (a) above can only be accomplished by breaking the stranglehold that government (primarily defense) agencies have on geospatial information. The primary issue on release of vast storehouses of geospatial information is whether release of the information compromises national and/or collective security. This issue alone is sufficiently complex to warrant another complete paper.

For the educational outreach program, however, Philip Condit, President and CEO of the Boeing Company, and J. Byron Pipes, President of Rensellaer

Polytechnic Institute offer a fantastic model for a "Global University."[23] If suitably adapted by and for the geospatial information community, the Global University model may help spark the evolution of a Global Spatial Data Infrastructure and eliminate the training void that exists today.

THE MODEL OF THE GLOBAL UNIVERSITY

Condit and Pipes recognize that engineering and fabrication for large multinational companies like Boeing is a 24-hour a day operation with work ". . . handed off 'down sun' in sequence to team members around the world. . ."[24] Because of this need for a widely dispersed, highly skilled workforce Condit and Pipes propose a model for a Global University that " . . . will better meet the current and future needs of multinational companies and the global engineer."[25] The model is relatively simple but offers a radical departure from the traditional university. Their recommendations are summarized in Table 1 below.

The needs of the geospatial information community are no less those of the global engineering company. With the transition from paper maps and grease pencils to geospatial information and computer screens it is obvious that with a force projection military like that of the United States that global availability of geospatial education is required to gain and maintain rapidly changing technical skills. American industry likewise is performing geospatial analysis on a global basis and requires global geospatial education.

1. Locate "remote campuses" near industrial customer(s)
a. Remote campuses include traditional classroom instruction, interactive multimedia, and distance learning
b. Training opportunities at remote campuses are available to local undergraduates
c. Remote campuses act as "technology parks" providing facilities and services tailored to the needs of local industry customers
d. Remote campuses act as the certifier of educators
2. Provide continuous education
a. Focused technical training for younger employees
b. Broad based technical training for maturing employees
c. Management and humanistic training for mature employees
3. Development and adherence to education standards to ensure that students at widely separated learning institutions receive the same education
4. Development of specialized "franchise" educational programs to commercial providers or other universities
5. Support for collaborative granting of academic degrees
6. Incorporation of industrial practitioners in academic training delivery

Table 1:Model for the Global University[26]

APPLYING THE GLOBAL UNIVERSITY MODEL TO GEOSPATIAL EDUCATION

The government's geospatial information training institutions, notably the National Imagery and Mapping College (NIMC), still clearly have the technological lead in the scope and availability of educational materials available for GIS/GPS/RSI exploitation. Unfortunately, as the defense budget is drawing down so too is the quality and frequency of update to those materials. Thus a major premise to the adaptation of the global university model for geospatial information education is for NIMC and the other DoD institutions to transfer many of their course materials to mainstream academia to take on the care and feeding of the courseware. This can be legally done using the current technology transfer laws (notably the National Technology Transfer and Advancement Act of 1995)[27]. In return for this sharing of courseware, the government should push for academia to adopt the Global University model as follows.

1. Locate "remote campuses" near industrial customer(s)

As mentioned earlier it's obvious that with a force projection military like that of the United States and the increasing global reach of the American geospatial information processing industry that global availability of geospatial education is required to gain and maintain rapidly changing technical skills. However, rather than rely on a single university locating remote campuses near military or industrial locations as Condit and Pipes suggest, it may be more advantageous to enlist the support of institutions already existing near military bases and industrial centers where the training is needed. An example of this would be to enlist the

support of Georgia Tech near Atlanta to teach GIS/GPS/RSI courses for potential military students at Ft. McPherson where the Army has a large geospatial information analysis cell. Georgia Tech can be supplemented by course material offered by NIMC and by NIMC instructors.

Another example is the need for GPS-technology education on the west coast of the United States where much of the aerospace industry (both government and industry) exists. GPS represents a dramatic improvement on air navigation and the west coast aerospace community would benefit from a series of short courses on GPS technology. UCLA's Extension University has an aggressive engineering seminar program that has supported their aerospace and remote sensing customers on the west coast but the seminar series lacks a GPS program. On the east coast of the United States, government agencies and research facilities (notably in the Washington DC area) have a need for short courses on sensor technology which UCLA's program currently offers but only on the west coast. NIMC's curriculum offers several short courses on GPS technology but none on sensor technology. Applying the technology transfer laws it is possible for UCLA and NIMC to legally transfer programs--UCLA instructors offering sensor technology programs at NIMC facilities on the east coast and NIMC instructors providing GPS training at UCLA facilities on the west coast. A further extension of this concept would be for NIMC instructors to teach the UCLA sensor technology program on the east coast and UCLA instructors to teach the NIMC GPS programs on the west coast with remote video feeds from subject matter experts.

In the case of government institutions, technology transfer laws allow research institutions to share facilities at no costs. For mainstream academia or private industry to benefit from adopting the government provided geospatial information courseware there of course must be a reasonable profit. The win-win solution is to allow these non-government institutions to use government training facilities to train not only government personnel but also private individuals. As an example of the *quid pro quo* agreements allowed by the technology transfer laws, rates for training government individuals may be significantly reduced while private individuals pay full price.

In the case where academia or industry establishes a facility nearby, the government can make equipment and adjunct faculty available to help augment the remote campuses' capabilities.

1.a. Remote campuses include traditional classroom instruction, interactive multimedia, and distance learning

Traditional classroom instruction is what both government and private training institutions excel at doing. Thus virtually no improvement is needed in classroom instruction. Interactive multimedia training is a different story--it is a very expensive proposition that most universities cannot easily afford to create from scratch. Experience has shown that DoD schools often get enough resources to create comprehensive multimedia training materials from scratch but are then unable to keep these materials updated to keep pace with technological innovations.[28] A good model to follow is collaborative efforts between DoD schools and academia whereby the DoD schools transfer the first generation multimedia

training to a partner at an academic institution or publishing house. In return, the partner must agree to periodically update, upgrade, and maintain the multimedia training and provide the updated material back to the government. The partner retains the rights to sell or franchise the training with the government's endorsement.

1.b. Training opportunities at remote campuses are available to local undergraduates

Taken to the extreme, maximum use of government- and/or industry-provided course materials at remote campuses by academic or industrial partners can eliminate much of the basic training government and industry are currently providing. Remote campuses will provide to undergraduates (for a fee) the same training that government and industry are currently providing newly hired college graduates. The remote campuses may eventually transition from the government providing post-hire basic training program to a non-government undergraduate degree program. Eventually, government and industry can eliminate much of their basic training (or retraining) and focus on advanced technology instruction.

1.c. Remote campuses act as "technology parks" providing facilities and services tailored to the needs of local industry customers

There are several options for a Government/Industry/ Academia partnership such as that being sought for the geospatial education community. These options are all variations on a theme based on one or more of the following concepts:

- Government provides space at within their operating locations and, through a technology partnership agreement, teams with a local university to operate the campus.

- Government and industry provide computer hardware for the campus' laboratories

- Industry provides software and initial software training for the instructional cadre

- Government and industry provide raw geospatial information

- Government, industry, and the university develop and maintain educational material

- Open the facility to all partners to perform testbed analysis, beta testing, training development, etc.

- The university provides the cadre of instructors-- government and industry provide adjunct instructors

Other solutions are subject to negotiation among the partners to each individual remote campus and the capabilities and facilities available to each partner.

1.d. Remote campuses act as the certifier of educators

Remote campuses will have instructors from academia, government, and industry that should be certified to guarantee quality of instruction. The remote

campuses vice the main campuses provide the most convenient method of providing certification. Of course this certification must be in accordance with standard academic certification processes. If, however, the remote campus is not equipped to perform this certification then another local university could be "franchised" to provide the instructional certification either at the remote campus or on site at their own facilities.

2. Provide continuous education

Companies like Motorola and Xerox operate their own corporate universities to train their employees on a spectrum of topics from basic technical skills to strategic leadership.[29] In the geospatial era, the federal government operates a pseudo-corporate university system. Training in the geospatial technology area is offered at NIMC and other DoD technical schools. Mid- and senior-level management and leadership training is offered at military service schools and Office of Personnel Management development centers. Agencies must compete among themselves for positions in these mid- and senior-level training institutions.

The burgeoning geospatial marketplace is marked by a small number of relatively large companies (2000 employees or more) and a large number of small entrepreneurial companies (200 employees or less) that provide GIS/GPS/RSI services to a variety of government and industry customers. The geospatial information market on the government side consists of increasing numbers of state and local planning, zoning, and tax collection offices.

Because the geospatial market is dominated by smaller businesses and state and local government offices, there is no focused "geospatial corporate university" that provides continuous education. The concept of a remote campus co-sponsored by government, the larger members of the geospatial industry, and academia can provide a corporate university opportunity for the smaller businesses and state and local governments that cannot afford to create their own. In addition, it can provide more training opportunities for federal government agencies that must compete for fewer training billets at the government's pseudo-corporate universities.

2.a. Focused technical training for younger employees

In the geospatial information arena younger employees typically need to round out their generalized education with a specific technical track. An example would be focused training on image interpretation for intelligence purposes, or collection of data to support cadastral surveys. Remote campuses offering a variety of short courses that focus training down these specific technical tracks are required.

2.b. Broad based technical training for maturing employees

As employees mature and become technical leads on projects, the need still exists for technical training but now on a broader scope of activities. An example of this in the geospatial arena is someone creating a cell of NIMA's new foundation feature data.[30] This includes not only image interpretation, but also data extraction, quality checking, control point verification, and data integration. Courses such as geospatial information production management, quality control measures, and database management, would be the focus of this training.

2.c. Management and humanistic training for mature employees

Although many management and humanistic courses are easily obtainable from a variety of local institutions the remote campus should select and package existing courses for the busy executive. Courses taught in a 16 week semester during normal business hours at a university may be condensed into short courses taught at the remote campus over a one or two week period to accommodate busy schedules.

3. Development and adherence to education standards to ensure that students at widely separated learning institutions receive the same education

Geospatial information education is only one of many technology areas that are suffering from the lack of education standards. In the United States two groups have stepped up to try to fill this void--the National Center for Geospatial Information and Analysis (NCGIA) and the DoD-sponsored Community Imagery Training Committee (CITC) and Community Geospatial Information Training Committee (CGITC).

In 1996 NCGIA proposed a core curriculum for Geospatial Information Science (GIScience).[31] The primary purpose of this core curriculum was to provide the academic community with a generic design of courses that act as the foundation of a comprehensive GIScience program.

The DoD efforts are under the auspices of the National Imagery and Mapping Agency (NIMA) as DoD functional manager for the United States Imagery and Geospatial Information System (USIGS) Community. The National Imagery and Mapping College (NIMC), as NIMA's functional manager designate for training

issues, is responsible for establishing training standards for imagery and geospatial information related activities throughout the DoD and intelligence community.[32] NIMC sponsors both CITC and CGITC, which are focused toward defining basic and advanced education and training requirements for military and DoD/Intelligence professionals. These professionals will eventually act in the capacities of Image Analysts, Terrain Analysts, or Geospatial Information processing specialists. CITC and CGITC intend to go beyond development of a core curriculum into developing actual course materials to be shared by DoD and Intelligence schools.[33]

Both the NCGIA and CITC/CGITC efforts have their strengths and weaknesses. NCGIA's primary strength is the nearly universal acceptance of the core curriculum by the GIScience academic community. The primary weakness is that many of the courses specified in the core curriculum are hollow shells--outlines for curriculum content that need to be fleshed out individually by the institutions that elect to implement these currently hollow courses.

CITC/CGITC's primary strength is the ability of their members to create state of the art course materials focused for their particular training needs. These course materials include lecture and lab materials that are unprecedented in the traditional university environment. Typical of the DoD/Intelligence community training environment is the use of current geospatial information processing hardware/software, imagery available only to US Government employees, and processing techniques taught by individuals with literally "battle-tested" skills. CITC/CGITC's primary weakness is that their core curriculum focuses not on the

achievement of a degree but in the certification of individuals to perform their duty tasks efficiently and effectively.

It is reasonably obvious that the NCGIA and the CGITC efforts are complementary. NCGIA has a draft geospatial information education core curriculum but little or no courseware. CITC/CGITC has access to, and management responsibility of, geospatial information training courseware but no core curriculum. Collaboration between NCGIA and CGITC to create and promulgate a geospatial information training education and training standard is clearly in both organizations' interests. A successful collaboration between NCGIA and CITC/CGITC could lead to the next discussion point of "franchising" educational programs.

4. Development of specialized "franchise" educational programs to commercial providers or other universities

This is the point where the most impact on geospatial information education may be felt. At present there are at least 800 U.S. colleges and universities offering geospatial information education of one form or another.[34] As mentioned above, there are neither national education standards nor any professional societies to provide *de facto* geospatial education standards.

The logical solution to the NCGIA and CITC/CGITC educational standards efforts are for these two groups to collaborate in the development and maintenance of a core curriculum then franchise the course materials to government, industry and academic institutions that wish to participate. The rich course materials that the CITC/CGITC have at their disposal can be provided to the NCGIA under the

auspices of the technology transfer laws.[35] Members of the NCGIA would be authorized and assisted by the Government schools to modify the course materials to make them more generic--in essence to "demilitarize" the courses. Then, in conjunction with a publishing house, course materials are packaged, marketed, and sold to participating institutions at a significant discount over most other science courses. These course materials could contain lecture materials, presentation graphics, and lab materials (e.g., satellite imagery, geospatial datasets, run-time versions of geospatial processing software, etc.) which would all be designed to run in a PC environment.

Thus is the initial set-up for geospatial education franchising--creation of a core curriculum in GIScience supported by prepackaged course materials made available to "franchisees" at attractive prices.

5. Support for collaborative granting of academic degrees

It is already recognized that the geospatial information community, particularly that of the DoD/Intelligence community, is widely dispersed around the world. Taking the franchise concept a step further is the granting of certificates and/or degrees to individuals that may have participated in programs administered by several academic institutions. Reviewing the help wanted sections in the geospatial industry trade journals (notably *GIS World* and *GeoInfo Systems*), industry is hiring individuals who hold a certificate typically from one of the large geospatial software houses (notably ESRI, Intergraph, and ERDAS). Thus a two-sided key here is for the ESRIs, Intergraphs, and ERDAS' of the world to allow

"franchisees" to award certificates where the awarding of certificates is the main draw of students to franchisee's programs.

Conceptually, students participating in the "franchise" program should be able to move around the country (or world), picking up courses along the way and eventually graduating from an institution with a degree and a certificate. Under current curriculum guidance many academic institutions are reluctant to award degrees to students who do not use that particular institution to complete the majority of their degree requirements. The way to overcome this reluctance will be to encourage franchisee institutions to award collaborative degrees. An alternative is for the National Imagery and Mapping College to offer accredited degrees and act as the accrediting authority of the franchisees. This may be difficult or impossible as the guidelines for federal degree granting authority may preclude a federally operated school from providing degrees where traditional academia currently offers similar degrees.

Certificate granting by franchisees is clearly the short-term solution. The long-term solution is to co-opt academia to provide collaborative degrees to graduates of franchised geospatial information education programs.

6. Incorporation of industrial practitioners in academic training delivery

Industry and institutions like the National Imagery and Mapping College should not only provide some of its employees as instructors to academia for periods of time but also allow academia and industry to spend internships at government and industrial facilities. Such internships will help increase the knowledge base of geospatial experts among academic institutions.

CONCLUSION

Many government functions in a capitalistic society exist to provide public goods and services where there are market failures. In the pre-geospatial era there was a failure of the market to provide these mapmaking and image analysis products and services. Participants in that pre-geospatial community consisted primarily of federal and state government agencies and a few small specialized geospatial data processing software and hardware houses beholden to the government for the majority of their business. Today, numerous small entrepreneurial companies, small state and local government offices, a handful of large companies and federal government agencies characterize the rapidly growing geospatial information market.

In the pre-geospatial training and education arena there was a similar market failure since the imagery analysis and mapmaking community was so small. This market failure was overcome by (1) government and military institutions developing and delivering indigenous high-quality geospatial training, and (2) government agencies sending full-tuition-paying students and research grants to a handful of large research universities specializing in the geospatial sciences. Academia has recognized there is no longer a "market failure" in the geospatial education and training area and is willing to provide training and education. Unfortunately the lack of standards for geospatial education and confusion about which academic department should "own" geospatial education

degree programs has resulted in a very shaky foundation for geospatial education in both academia and private industry.

The government clearly has two options with respect to helping academia create a stable foundation for geospatial information education--do nothing or get actively engaged as a leader within the larger geospatial information education and training community.

If the federal government institutions sit idly by and do nothing, American academic institutions will lose the benefit of decades of experience and skill available in federal government training institutions. Moreover, because the majority of academic institutions are nearly starting from square one with geospatial education programs it will take years and perhaps decades to get geospatial information curricula fully developed. Lastly, since the federal government geospatial training programs are paid for with taxpayer dollars, it is shortsighted for the federal government not to transfer these curricula to private academia.[36]

Taking a leadership role in the geospatial educational community means that the federal government training institutions must make available copious amounts of "intellectual property." Examples of intellectual property include course syllabi, presentation graphics, course content documents, instructor guides, textbooks, lab materials, and most importantly subject matter experts and expertise. It will take a significant time investment by subject matter experts to successfully transfer course material to academia and this potentially is lost instruction time. However, the transfer into a franchise education scenario will work like a pyramid scheme--a

successful franchisee certifies two more franchisees, who each certify two more--soon there are numerous outlets for training in an area that was formerly the exclusive purview of the federal government. If successful, the federal government could outsource much of its heretofore internal basic training to franchised operations. Government training institutions could then focus on providing training for those parts of the geospatial information processing technology areas that are still market failures— e.g., analysis of new and/or classified remote sensing systems and imagery.

In conclusion, the preferred solution to eliminating the void in geospatial education is for the large federal government agencies and large geospatial systems manufacturers to partner with academia to create geospatial education standards and adapt the Global University Model proposed by Condit and Pipes for geospatial education. This strategic partnership of government, industry, and academia will lead to rapid transfer of geospatial technology and training techniques to academia. Accompanied by the stewardship of industry and government, academia can rapidly fill the void in geospatial information education and training for the benefit of all.

ENDNOTES

[1] Leslie Wayne, "The Shrinking Military Complex," New York Times, 27 February 1998, sec C, p. 1 & 6.

[2] Al Gore, "National Performance Review," available from <http://www.npr.gov>; Internet; accessed 16 January 1998.

[3] Department of Defense, "Report of the Defense Reform Initiative," (Washington, DC: US Department of Defense, 1997).

[4] "Federal Property and Administrative Services Authorization Act of 1992," available from <http://thomas.loc.gov>; Internet; accessed 23 January 1998.

[5] Joint Chiefs of Staff, Joint Tactics, Techniques, and Procedures for Geospatial Information and Services Support to Joint Operations, Preliminary Coordination Draft Joint Publication 2-03 (Washington, DC: Department of Defense, 1997).

[6] "URISA Attendees Predict Explosion in GIS Use," American City and County, 112, no. 11, (Oct. 1997): 8.

[7] Ibid.

[8] Defense Mapping Agency, DMA Chart Compilation Process, (St. Louis, MO: Defense Mapping Agency, 1979.)

[9] William B. Wood, "A Jeffersonian Vision for Mapping the World," Issues in Science and Technology 14, no. 1 (1997): 82.

[10] Remote Sensing Imagery (or remotely sensed imagery) is any imagery obtained from a sensor that is not in direct contact with the object being imaged. Most typical of RSI is electro-optical imagery in the visual and infrared portions of the electro-magnetic spectrum (also known as multi-spectral imagery or MSI) and RADAR imagery.

[11] Geographic Information Systems (GIS) are integrated hardware/software geographic database management systems that can both generate and exploit map or other geographic information. In the military, GIS are often used to determine cross-country trafficability for personnel and materiel by comparing such things as soil type, slope, vegetation cover, load-bearing capability of roads and bridges with parametric information of the vehicles being moved. Example: GIS is used by Army terrain teams to find the optimum route to move a 60-ton M1A1 tank by finding routes containing (a) bridges that are wide enough and sturdy enough to handle the size/weight of the tank, (b) on slopes that the tank can easily negotiate, (c) through soils that are unlikely to bog the tank down, (d) through terrain that does not give a potential enemy an advantage. In the civilian sector, GIS is often used for facilities management, environmental management, forestry, agriculture, and tax assessment.

[12] Global Positioning System is a DoD system that provides precision navigation and positioning services to anyone, military or civilian, with a GPS receiver. The GPS system was fully operational in 1993.

[13] Tim Howard, "Summary of Commercial Satellite Information," briefing, Reston, VA, Remote Earth Sensing Working Group, 7 May 1996.

[14] Chester C. Slama, Charles Theurer, and Soren W. Henriksen, Manual of Photogrammetry (Falls Church, VA: American Society of Photogrammetry, 1980), 139-150.

[15] Ibid.

[16] The National Imagery and Mapping College (NIMC) is the training arm of the National Imagery and Mapping Agency (NIMA). NIMC's Defense Mapping School provides joint service Military Occupational Specialty (MOS) qualifying terrain analysis and surveying training to both national and international military students. NIMC's National Imagery and Analysis School provides imagery analysis basic and advanced training to NIMA employees. The US military services, through their respective intelligence schools at Ft. Huachuca (Army), Goodfellow AFB (Air Force), and Dam Neck (Navy/Marines), provide MOS-qualifying imagery analysis and map exploitation training to their students. Presently, none of the aforementioned schools provide accredited degrees to graduates of geospatial-related programs.

[17] Analysis by the author of findings in John M. Morgan III, Bobby Fleury, and Richard A. Becker, 1996 Directory of Academic GIS Education (Dubuque: Kendall/Hunt, 1997).

[18] Ibid.

[19] Ibid., 3.

[20] Joseph K. Berry, "Academia Grapples with GIS Definitions," GIS World, July 1997, 26.

[21] Wood, 84.

[22] Ibid.

[23] Philip Condit and R. Byron Pipes, "The Global University," Issues in Science and Technology 14, no. 1 (Winter, 1997): 27-28.

[24] Ibid., 27.

[25] Ibid.

[26] Ibid, 27-28.

[27] National Technology Transfer and Advancement Act of 1995, US Code Congressional and Administrative News, 104th Congress--2nd Session 1996 (St. Paul: West Group, 1997)
vol. 1.

[28] View based on the personal experience of the author as Technical Director of National Imagery and Mapping College, Ft. Belvoir, VA from 1996-1998.

[29] Michael Marquardt and Angus Reynolds, The Global Learning Organization (Burr Ridge, IL: Irwin Professional Publishers, 1994), iii.

[30] Geospatial Information Integrated Product Team, Geospatial Information Infrastructure Master Plan, (Bethesda, MD: National Imagery and Mapping Agency, 1997) Vol. 3, 49.

[31] National Center for Geospatial Information and Analysis, "The NCGIA Core Curriculum in GIScience," available from *<http://www.ncgia.ucsb.edu/education/curricula/giscc/giscc/html>;* Internet; accessed 8 August 1997.

[32] National Imagery and Mapping Agency, Functional Manager's Guidance for the U.S. Imagery and Geospatial Information System Community, (Fairfax, VA: National Imagery and Mapping Agency, 1997), 11.

[33] National Imagery and Mapping College, NIMC Training Management Plan, (Ft. Belvoir, VA: National Imagery and Mapping College, 1997), 1-2.

[34] Morgan, et. al.,

[35] National Technology Transfer and Advancement Act of 1995, 104th Cong. 2nd sess., 1997. (St. Paul: West Publishing Co., 1996), section 2.

[36] Ibid.

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